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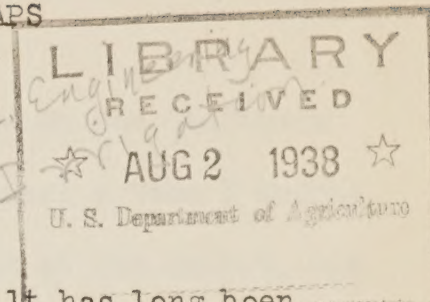
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## VORTEX-TUBE AND RIFFLE-DEFLECTOR SANDTRAPS

By

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The deposition of water-borne gravel, sand, and silt has long been recognized as one of the most troublesome problems incident to the operation and maintenance of many of the irrigation and power canals of the West. Inordinate expenditures of time, labor, and money are made annually on this account. The reduction in the carrying capacity of a canal used for the delivery of water for either irrigation or power development means direct financial loss. Furthermore, the inert material deposited upon irrigated land decreases the soil fertility, and, by raising the land surface near the margin of the field, interferes with the spreading of the water evenly over the tract.

To eliminate this element of deterioration and cost, the Colorado Agricultural Experiment Station, in cooperation with the Bureau of Agricultural Engineering of the U. S. Department of Agriculture, is conducting experiments on two different kinds of sandtrap, called the vortex-tube type and the riffle-deflector type.

The Vortex-Tube Type

The main feature of the vortex-tube sandtrap is a tube with an opening along one side, laid in the bed of the canal at an angle of about 45° to the general direction of flow, and with the opening uppermost. As the water flows over the opening, a pronounced whirling or vortical motion is set up within the tube, and a spiral-flow action extends throughout its length. This rapidly whirling cross-stream draws in the material traveling along the bed of the canal, sometimes called the "bed load" as it passes over the lip of the





opening and carries it to an outlet at the downstream end of the tube whence it is discharged into a suitable sluiceway. (Figure 1.)

An experimental channel 6.13 feet wide was installed at the Station's Bellvue hydraulic laboratory. In the bottom of this channel a tube 7 inches in diameter at the upstream end and 10 inches in diameter at the outlet, was laid at an angle of inclination to the channel axis of about  $53^\circ$  and with the lip of the tube level. The floor downstream from the lip was made about 4 inches lower than that above. For these experiments, the water-depth over the lip of the tube was maintained at about 1 foot, and tests were made with mean channel velocities ranging from less than 1 foot to more than 3 feet per second and with various percentages of the total flow discharging through the outlet.

The rate of rotation of the vortex was observed by using special 3-vaned turbines. The translation velocity was observed by means of a light-weight diaphragm traveling along a wire stretched tightly along the axis of the tube. For the trap studied, the best results were obtained with a mean channel velocity across the lip of the tube of about 2.7 feet per second, a 9-inch depth of water in the channel, and from 10 to 15 percent of the total flow escaping through the discharge outlet. Under these conditions, the rate of rotation was found to be more than 200 revolutions per minute, with translation velocities of from 1.5 to 2.0 feet per second. Heavy sand and cobblestones as large as hens' eggs were readily ejected.

Further investigations in 1932 on a 4-inch tube of uniform diameter have been made, covering a wider range of velocities, slopes and inclinations to axis of channel in combination with various controlled discharges over and through the tube. The maximum of 300 revolutions per minute was observed within the tube and the energy created therein was sufficient to move a cobblestone weighing  $7\frac{1}{2}$  pounds at a uniform speed of about  $1\frac{1}{2}$  foot per second







to the outlet, a distance of about 7 feet, with a mean velocity of 6.6 feet per second over the tube, and the axis of the tube at  $30^{\circ}$  to the axis of the channel, floor of channel upstream sloping to outlet side 2 inches in 4 feet, and 3 percent of total flow through the tube. For the same 4-inch tube with upstream floor level and axis of tube  $45^{\circ}$  to axis of channel and a mean velocity of 6.9 feet per second over the tube, the maximum of 500 revolutions per minute was observed, but in this case the maximum weight of cobblestone transported was about  $4 \frac{3}{4}$  pounds.

A vortex-tube sandtrap, designed in accordance with conclusions based on the preliminary laboratory studies, has recently been installed in the Owen and Hall Ditch, on the Roby ranch at Fountain, Colorado, at a cost of about \$100 and has been operated successfully. The owner of the ditch states that he believes the trap has caught at least 90 percent of the bed load.

There has not yet been sufficient study of the vortex-tube trap to permit arriving at definite conclusions as to the proper dimensions and characteristics, such as diameters, angle of inclination to axis of flume, form of opening, and slope and taper of tube, in relation to the velocity of the water flowing in the channel.

#### The Riffle-Deflector Type

The riffle-deflector sandtrap consists of a series of curved sheet-metal plates, each approximately in the shape of the quadrant of a circle and bent to a  $90^{\circ}$  arc horizontally and with top edge rolled, attached to a smooth flume floor having a lateral slope. Experiments made with these deflectors included observations on various shapes, sizes, spacings, and arrangements of settings.

The action of the water passing a line of deflectors is, in general, about as follows: The obstruction offered causes a rolling of the water just downstream from or immediately behind the line of deflectors. The direction of rotation of this roll where it contacts with the floor is upstream, and







this condition causes the sand and silt to be held back close to the downstream edge of the line of deflectors. The water passing between the deflectors moves laterally, or in a direction parallel to the line. The combined action holds back the bed load and at the same time transports it laterally to the side of the channel where an opening is provided in either the floor or the side wall of the flume, through which the captured solids, together with a part of the water, are discharged.

Experiments with a set of riffle deflectors, each about 8 inches high and set 10 inches apart in a line perpendicular to the axis of the channel of an 8-foot flume, demonstrated that it is possible to transport the bed load in a direction at right angles to the general flow direction; (Figure 2.); also, with the deflector farthest from the opening placed 8 feet downstream from the outlet and with the line of deflectors at an angle of  $135^{\circ}$  from the axis of the channel (Figure 3), remarkable results were obtained, cobblestones weighing more than a pound, as well as sand, being readily moved upstream and ejected through the outlet. In other words, they were carried obliquely upstream along a path inclined  $135^{\circ}$  from the direction of the general flow, across the channel to the outlet.

An experimental riffle-deflector sandtrap has been installed in the Wanamaker Ditch near Golden, Colorado. In this set-up, there were five lines of curved metal deflectors, each 6 inches high, spaced about 6 inches apart in lines at right angles to the axis of the channel. Each line of deflectors was provided with an individual outlet and just upstream from the first set there was a set of special deflectors set in lines making an angle of about  $45^{\circ}$  with the axis of the channel. These upstream deflectors moved a large portion of the bed load to an 8 by 8-inch opening in the flume wall. This outlet, with the other five, discharged into a common sluiceway leading back to Clear Creek, the stream from which the supply for this ditch is obtained. By using







special sampling apparatus it was found that, under the most favorable conditions, the trap was removing more than 600 tons of sand from the ditch every 24 hours with a flow in the ditch of approximately 10 second-feet and with about 2 1/4 second-feet returned to the stream. The excessive sand load in the stream was thought to be due to the accumulation of mill tailings from the stamp mills along this stream in the mountains, the spring high water flow bringing the material down in abnormal amounts.

The Wanamaker ditch sandtrap is seriously handicapped, owing to the great amount of rubbish that is brought down Clear Creek. Such materials as old auto tires, tin cans, cardboard cartons, rags, clinkers and other trash interfere very materially with its operation.

#### General Conclusion

The experiments thus far made seem to indicate that these devices will be widely useful. They also appear to show that the riffle-deflector type requires less waste water in its operation than does the vortex-tube. From a laboratory standpoint they appear to be about equally efficient. Both types are covered by public patents.





Fig. 1  
 SKETCH OF  
 VORTEX TUBE  
 AS ARRANGED  
 IN FLUME

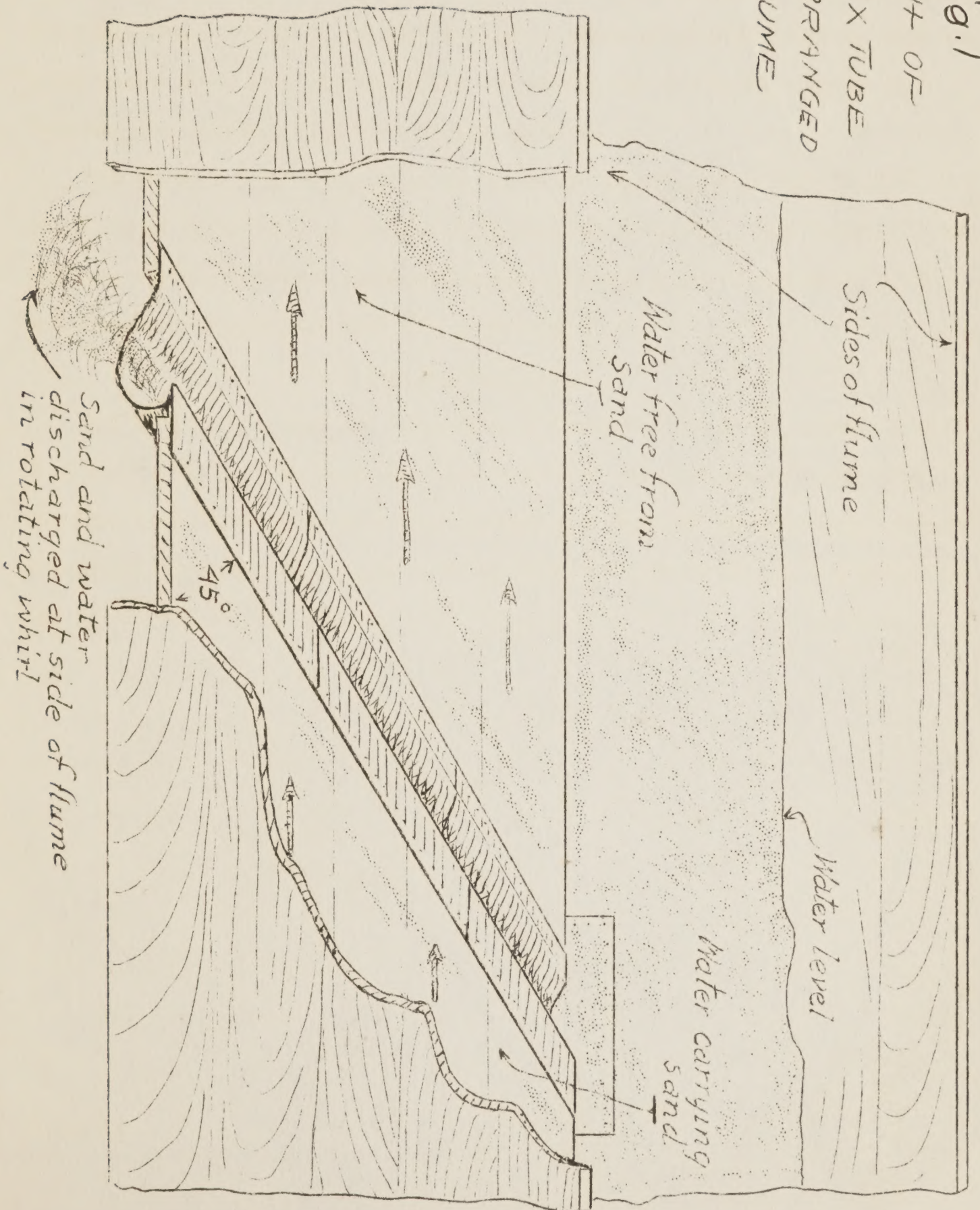








Fig. 2  
SKETCH OF  
RIFFLE  
DEFLECTOR  
ARRANGED  
AT  $90^\circ$

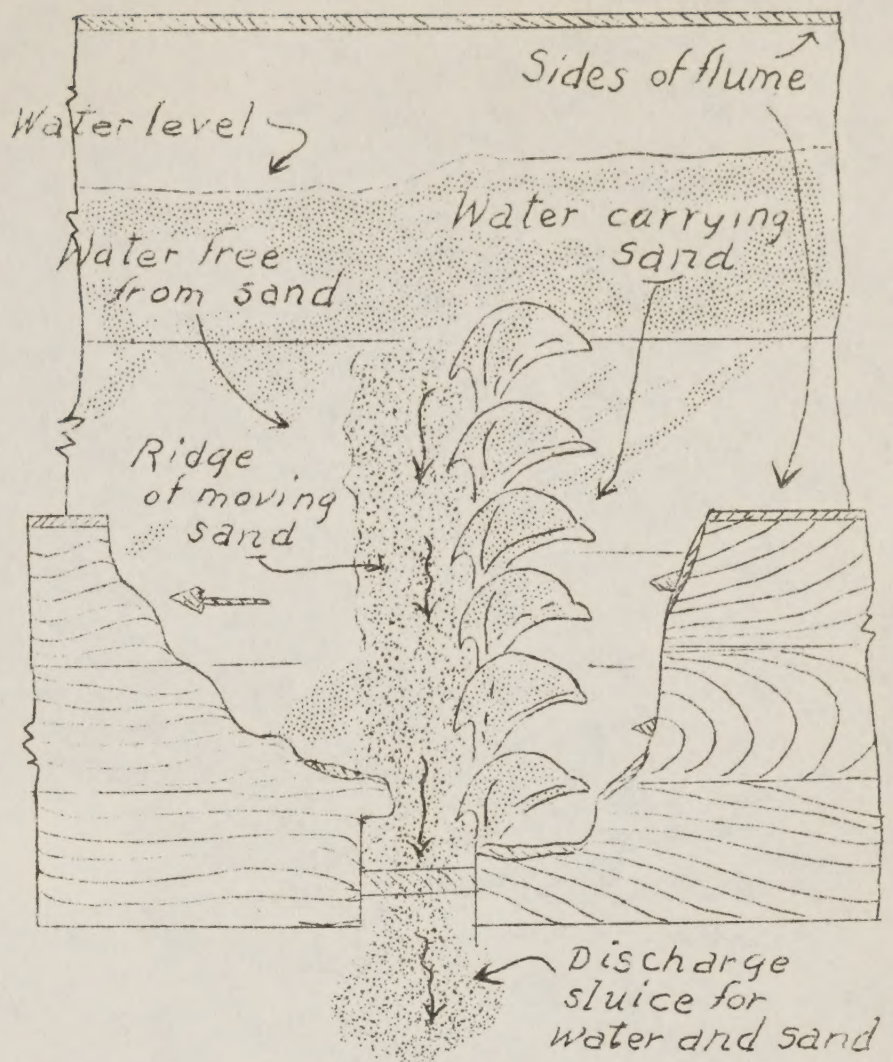
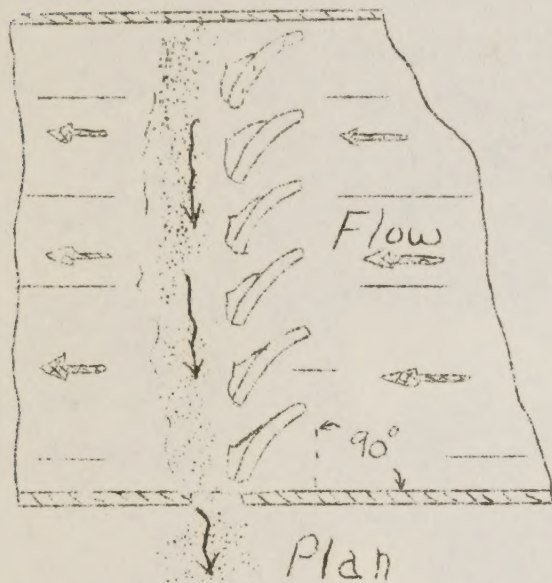


Fig. 3  
SKETCH OF  
RIFFLE  
DEFLECTOR  
ARRANGED  
AT  $135^\circ$

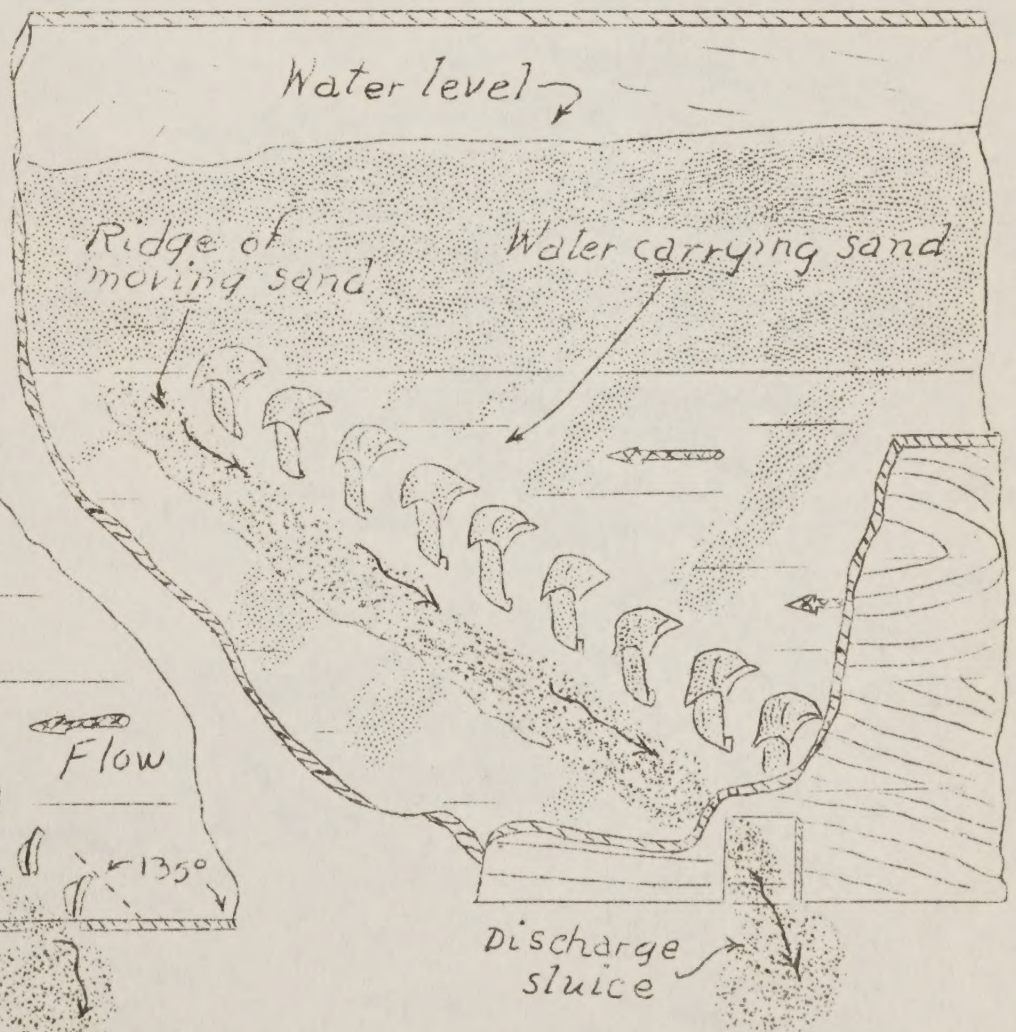
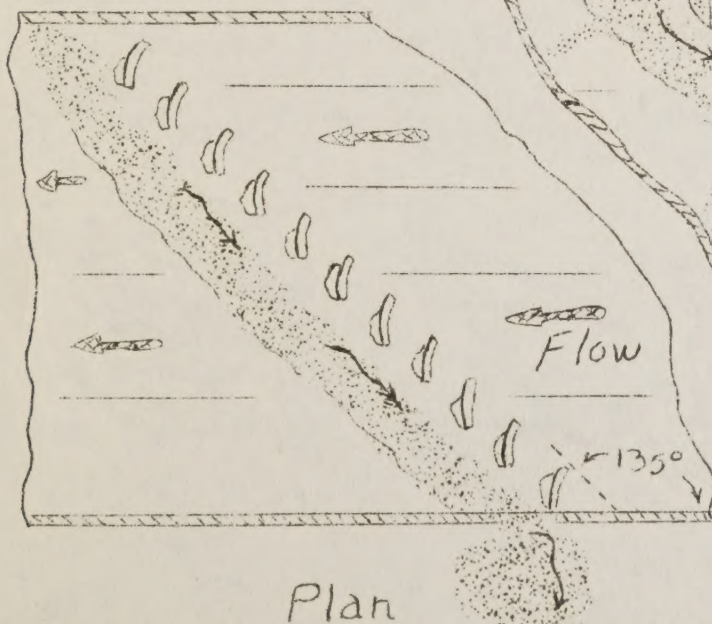
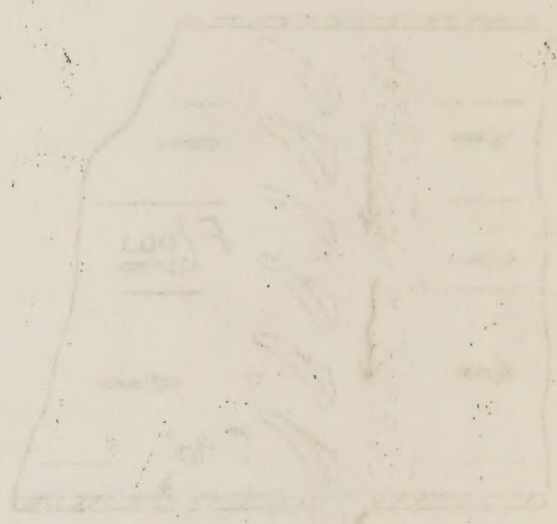
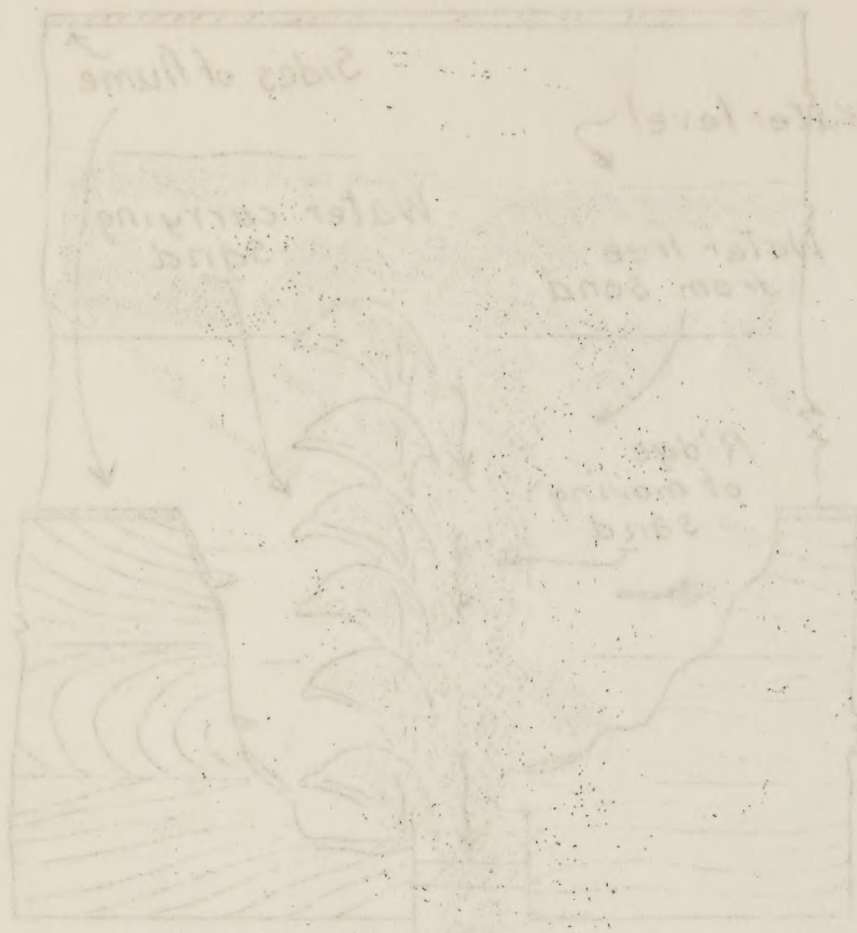




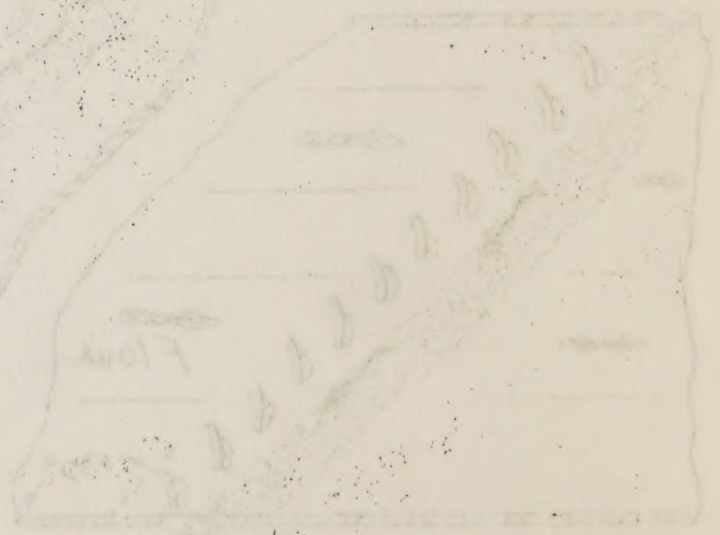
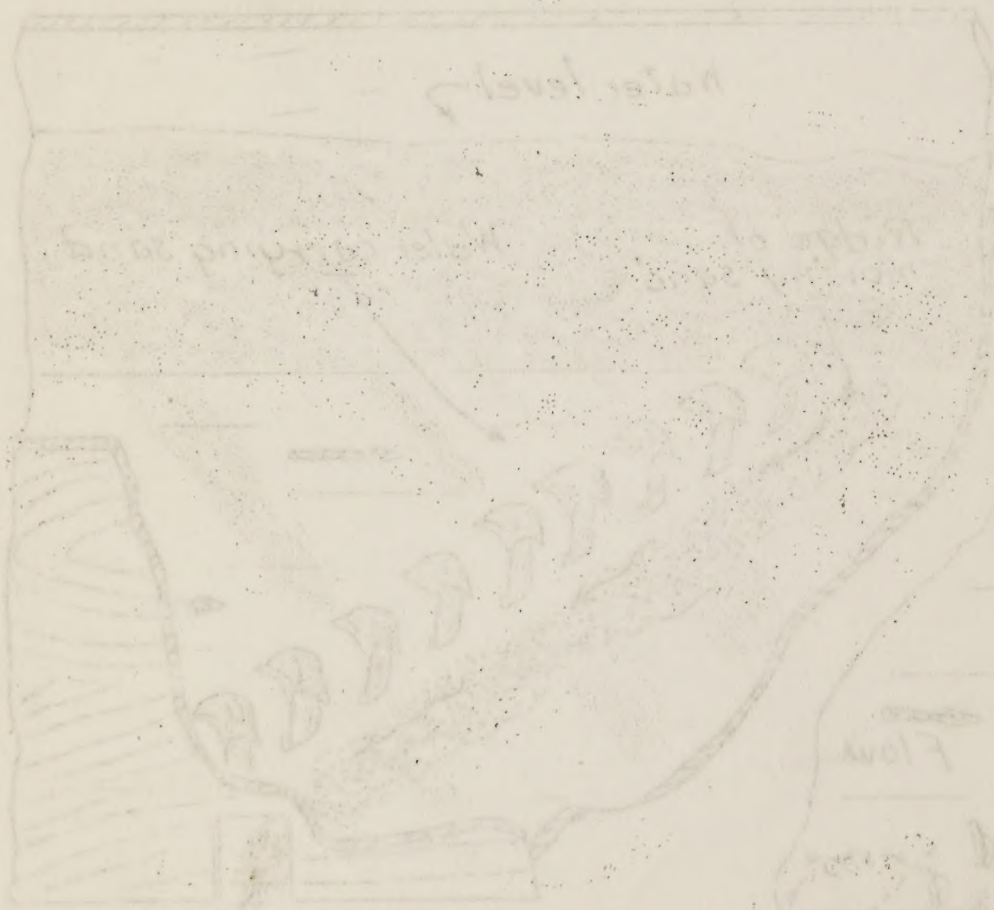
Fig. 2  
 SKETCH OF  
 RIVER  
 DEFLECTOR  
 ARRANGED  
 AT 90°



Plan

Discharge  
 since for  
 water and sand

Fig. 3  
 SKETCH OF  
 RIVER  
 DEFLECTOR  
 ARRANGED  
 AT 135°



Plan

Discharge  
 since